EP-1259: Influence of the type of headrest (individual or standard) on the actual given dose in target volumes and organs at risk

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	Ref contour	Up post	Up ant	Up right	Up left	Low post	Low ant	Low right	Low left
SUPINE POSITION Van Herk margin	1st fraction	6.9	16	8.7	12	8.6	17.8	11.6	12
	median	2.9	6.2	4.5	4.4	2.6	4.3	2.6	2.8
	half fraction	4.9	7.6	5.1	7.5	5.4	8.1	4.8	10
	median 2nd part	2.8	5	3.4	2.6	3	3.9	2.4	3.1
PRONE POSITION Van Herk margin	1st fraction	7.2	9.3	8	8.6	4.2	6.6	6.1	7
	median	7	7.5	7.7	8	4.9	3.5	4.4	3.8
	half fraction	15.8	9.8	12.8	15.9	9.8	5.1	8.4	7.9
	median 2nd part	8.3	6.9	7.9	6.9	5.3	3	4.2	3.9
SUPINE POSITION M(90,100)	1st fraction	4	10.7	6.5	5.4	2.8	12	5	5.3
	median	4.5	9.5	8	6.3	5.8	6.4	6.4	7.3
	half fraction	3	7.9	3.8	4.9	4.9	7.2	4.2	11.7
	median 2nd part	6.2	6.8	4.1	3.7	4.1	5.2	3.7	4.8
PRONE POSITION M(90,100)	1st fraction	7	13.4	9.3	10.7	5.9	6.5	6.9	7.2
	median	12.9	14.8	10	12	9.9	6	7.3	7.7
	half fraction	14.7	13.2	12	17	14.1	6.9	11.4	11.3
	median 2nd part	13.3	11.2	10.3	11.7	10.7	5.6	7.7	8.1

Conclusions: Local 3D changes of rectal shape show an anisotropic motion of rectum for both supine and prone pts and larger margins for prone pts when considering the second half of treatment, although it could be due in part to a different gender distribution in the two groups. Daily imaging combined with 3D local shape quantifications permits to fully include deformation into local margin assessment.

EP-1258

Impact of the spinal cord position uncertainty on the dose received during head and neck helical tomotherapy

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Purpose/Objective: To establish the optimal planning risk volume to the spinal cord (SC) for oropharyngeal cancer patients during adaptive radiation therapy with concurrent chemotherapy (CRT).
Materials and Methods: Prospective study based on the 875 observations from 25 oropharyngeal cancer patients was performed. Geometrical uncertainties of the SC were evaluated. Differences between planned and delivered maximum doses to four parts of the SC (C1-C2, C3-C4, C5-C6, C7-Th1) were established for every fraction dose and for cumulative dose. Maximum doses were evaluated as a dose received in 0.5 cm^3 and 1 cm^3 of the analysed part of the SC. Finally, relations between dose differences and geometrical uncertainties were analysed using a relative risk (RR), dose gradient (DG) and the importance of the PRV dose gradient (IDG) to establish optimal planning risk volume for the SC. The importance of the dose gradient (IDG) was established for each part of the SC as the ratio of the maximum dose received in a part of the PRV corresponding to the analysed part of the SC to the maximum dose in a whole PRV. The relative risk (RR) was defined as a ratio of the maximum delivered dose in selected part of the SC ($D_{Delivered}$), to the maximum dose in the whole PRV (D_{PRV}) multiplied by IDG: ($RR=D_{Delivered}/D_{PRV}$ x IDG).
Results: The C1-C2 part of the SC is most exposed to risk of over-dosage during chemoradiation for patients with oropharyngeal cancer due to its proximity to the CTV. Doses received by other parts of the SC are smaller, with the lowest dose delivered to C7-Th1. Results of the detailed analysis of the maximum doses received in selected parts of the SC are described in Table.

Region	Dose in 1 cm^3 and (0.5 cm^3) [Gy]			Dose Parameters for 1 cm^3 and (0.5 cm^3)	
	Planned in SC	Delivered to SC	Planned in PRV	Importance of Gradient	Relative Risk
C1-C2	29.9 (31.6)	31.4 (35.1)	38.1 (40.1)	1.0 (1.0)	0.8 (0.9)
C3-C4	25.4 (27.1)	26.7 (30.5)	34.4 (35.7)	0.9 (0.9)	0.6 (0.7)
C5-C6	17.9 (18.8)	18.8 (20.9)	24.3 (26.8)	0.6 (0.7)	0.3 (0.3)
C7-Th1	12.0 (12.9)	12.6 (13.8)	15.6 (17.1)	0.4 (0.4)	0.1 (0.1)
Whole SC	29.9 (31.6)	31.4 (35.1)	38.1 (40.1)	1.0 (1.0)	0.8 (0.9)

The lowest movement of individual parts of the SC were detected for the C1-C2 and the highest for the C7-Th1. Mean shifts were close to zero, ranging from 0.6 mm in the x-axis for the C6-Th1 to -0.8 mm in the z-axis also for the C6-Th1. Analysis of the distribution of the shifts shows that the highest standard deviations were observed for the C6-Th1 (2.7 mm, 1.3 mm, and 2.9 mm for the x, y, and z axes, respectively) and the lowest for the C1-C2 (1.4 mm, 0.9 mm, and 1.1 mm for the x, y, and z axes, respectively).
Conclusions: The likelihood of over-dose in the spinal cord is most affected by the geographical location to the PTV. The C1-C2 part of the spinal cord is most exposed to risk of over-dose during CRT in patients with oropharyngeal cancer. Doses received by other parts of the SC are smaller, with the lowest dose delivered to the C7-Th1. The mobility of the individual parts of the spinal cord were different for different parts of SC: the lowest for the C1-C2 part and the highest for the C7-Th1.Finally, our study showed that for CRT of the oropharyngeal cancer with daily image guidance and proper plan adaptation scheme, the currently used PRV margin for the spinal cord (5 mm) could be reduced to 4 mm.

EP-1259

Influence of the type of headrest (individual or standard) on the actual given dose in target volumes and organs at risk

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Purpose/Objective: In head and neck radiotherapy, headrests and masks are used to immobilize the treatment region. The type of headrest used, e.g. individual or standard, can have an impact on the positioning reproducibility e.g. the flexion of the neck. It is expected that a better positioning reproducibility will result in less deviation of the actual given dose in relation to the planned dose. The purpose of this study was to investigate the influence of the type of headrest on the actual given dose in target volumes (TVs) and organs at risk (OARs) in head and neck cancer patients in case of no and off-line position corrections.
Materials and Methods: Planning-CT scans (pCT) before treatment and repeat-CT scans (rCT) in the last week of treatment were acquired in 9 head and neck cancer patients, using an individually moulded and a standard headrest. All patients could be treated with fields sizes smaller than 16 cm x 21 cm. All TVs and OARs were delineated on the pCT for both headrests by a head and neck radiation oncologist. Treatment plans were optimized in Pinnacle Research 9.1 using similar criteria for both pCTs. Contours from the pCT were deformed to the corresponding rCT with a fast symmetric demons algorithm, and manually adjusted if necessary. The actual given dose was estimated by the dose calculated on the rCT. Two different situations were simulated: 1) no position corrections; 2) off-line position corrections according to the Shrinking Action Level (SAL) protocol. The average dose to the high-dose-CTV and -PTV, ipsi- and contralateral parotid glands and the maximum dose to the spinal cord in a 2 cm^3 volume were determined for the two situations.
Results: Irrespective of the use of position corrections, doses increased (given dose *minus* planned dose) up to 6.0 and 3.6 Gy were found for the ipsi- and contralateral parotid glands, respectively. For the spinal cord, doses increased up to 2.9 and 2.3 Gy in the case of no and off-line position corrections. Fig 1 shows the average dose increase for the 9 patients between the rCT and the pCT with the corresponding standard deviations (SD) for different regions of interest and both headrests with and without position corrections. The average dose increase was smaller using the individual headrest for the high-dose-CTV and -PTV and all investigated OARs, except for the contralateral parotid glands. However, the average dose differences between both headrests with and without position verification were smaller than the SDs.
Conclusions: For patients treated with the individual headrest the average dose increase during the course of treatment (given dose *minus* planned dose) was smaller than with the standard headrest. This smaller dose increase was observed both in the target volumes and the ipsilateral parotid gland and the spinal cord. For the investigated cohort of 9 patients, with relatively small field sizes, the differences between the two headrests with and without position verification were not significant.

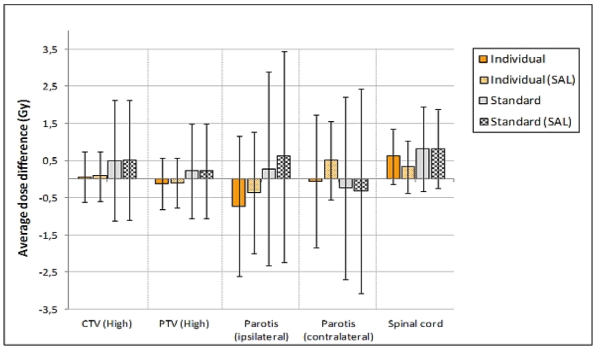

Fig 1. Average dose difference (given dose *minus* planned dose) for the individual and standard headrest in different regions of interest with the corresponding standard deviations. From left to right, without and with off-line Shrinking Action Level (SAL) patient corrections.

EP-1260

Evaluation of individual margins to account for motion during the treatment of moving targets

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Purpose/Objective: Treatment planning and dose calculation are based on static images in radiotherapy. But some targets are subject to regular movements like breathing motion. Profile and magnitude of motion affect the applied dose leading to dose blurring. Taking into account motion during treatment, margins around the target are used to compensate motion induced effects on dose distributions. As magnitude of motion is patient specific, the associated margin has to be individual. The aim of this work is to analyze the effect on dose distributions. Parameters having an impact are amplitude and target size. Individual margins are investigated to compensate for motion induced dose blurring resulting in a better adapted treatment for each patient.

Materials and Methods: Simulating different sized lung targets, Gafchromic EBT2 films (ISP, Wayne) are irradiated using a static thorax phantom. Different target and margin related field sizes are measured. Transmission of the film is determined with a flatbed scanner, evaluation and extraction of dose profiles are executed with MATLAB routines (R2011a, TheMathworks). The static dose profiles are blurred with MATLAB simulating breathing motion (symmetric $\cos^4$ function) with peak-to-peak-amplitudes in the range of 0-30 mm in the direction of the profile. The target region of the profile is analysed in static and motion case each having various margins. Mean dose and EUD of the target region are calculated for several target sizes and compared for different combinations of motion amplitudes and margins.

Results: In figure 1, EUD of the target region as function of the applied margin is shown for different motion amplitudes. Data are normalized to the value without motion and margin. For a moving target, EUD and mean dose decrease with increasing motion amplitude. Magnitude of this effect depends on the target size, additionally. To reach the same EUD and mean dose in case of motion as in static case, a margin has to be applied. Thus EUD and mean dose increase for all amplitudes and target sizes, but not in the same ratio. For growing target size the margin decreases for a constant amplitude, because the shape of the field edges change with size. Therefore, individual margins have to be determined considering individual motion amplitude and target size.

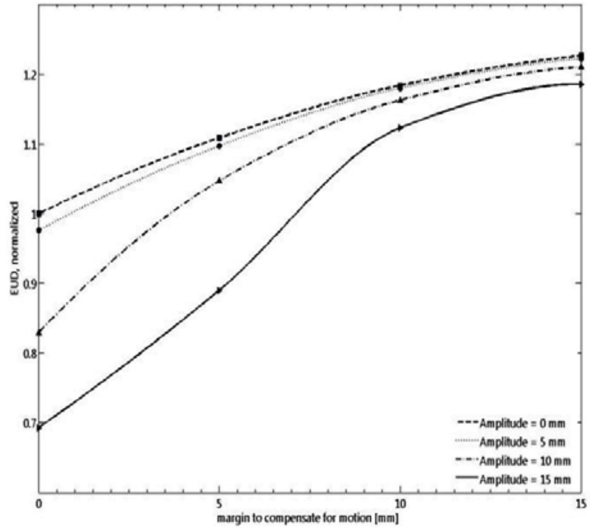

Figure 1: EUD of the target region as function of the applied margin for different motion amplitudes.

Conclusions: Individual margins are important applying the treatment best possible for each patient. To compensate for motion effects, the margin must depend not only on motion amplitude but also on target size. In the future, a mathematical correlation is quested for to calculate an individual margin for known motion amplitude and target size.

EP-1261

Impact of polyethylen glycol spacer injections on interfraction prostate motion in patients undergoing IGRT

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Purpose/Objective: The injection of a polyethylen glycol spacer (PGS) in the *Denonvilliers* fascia aiming to separate the prostate from the anterior rectal wall has been recently introduced for curative radiotherapy (RT) delivered to patients with localized prostate cancer. Sparing of the rectum from the high RT doses with PGS will be achieved and a decrease of radiation-induced toxicities is awaited. In this study we assessed the impact of PGS in the interfraction prostate motion in patients undergoing curative RT for prostate cancer.

Materials and Methods: Twenty patients with (n=10) or without (n=10) PGS were treated to the prostate ± seminal vesicles according to a hypofractionated RT protocol (14x4 Gy, twice/thrice-a-week). All patients were implanted with three fiducial markers (FM) before the start of RT and underwent between 4 to 8 cone-beam computed tomography (CBCT) scans during the RT course. Constant bladder and rectal filling was controlled by proper patient instruction and, if necessary, using rectal enemas before every RT fraction. Relative displacements between the prostate isocenter based on the FM's position and the bony anatomy were quantified in the LR (left-right), AP (anterior-posterior), SI (superior-inferior) axes for every patient by offline analyses of CBCTs. A total of 122 CBCTs were evaluated. Systematic (Σ) and random (σ) setup errors were determined and planning target volumes (PTV) margins computed with the Van Herk formula (= 2.5 Σ + 0.7 σ).

Results: The overall mean errors and the average of the standard deviations of the prostate displacements during the RT course were -0.03 and 0.67 mm, 0.35 and 1.60 mm, and -0.26 mm and 1.56 mm for the LR, AP, and SI axes, respectively. A mean interfraction motion ≥ 4 mm was observed in LR, AP, and SI directions in 0, 3 (15%), and 2 (10%) patients, respectively. Mean prostate interfraction movements in patients treated with or without PGS were 0.32 mm *vs.* -0.38 mm, 0.12 mm *vs.* 0.59 mm and -0.36 mm *vs.* -0.17 mm in the LR, AP and SI directions, respectively. Despite an overall prostate motion less marked of 0.44 mm in the AP direction for patients with PGS, the Σ and σ errors remained similar for both groups in the three axes. Estimated PTV margins using a CBCT-based bony alignment were similar for patients treated with or without a PGS implant, requiring 1.97 mm *vs.* 2.11 mm, 8.92 mm *vs.* 8.55 and 7.19 mm *vs.* 6.63 mm for the LR, AP and SI axes, respectively.

Conclusions: The implant of PGS does not significantly influence the interfraction prostate motion in patients treated with curative RT for